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PROTECTION FROM THE LOCUST BORER.

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INTRODUCTION.

The increasing value of black or yellow locust[1] for many purposes, and especially the recent demand for sound locust pins or treenails in the construction of wooden ships, render its protection from insect damage important.

In addition to the natural growth of locust in forests, farmers' woodlots, and abandoned fields, many attempts have been made to grow it on a commercial scale in plantations. These attempts in most cases have resulted in failure, owing to the serious damage to the wood and frequently the destruction of the trees caused by the locust borer.[2] The fact, however, that in natural growth and occasional plantations practically no injuries from the borer are found, while in other cases the trees are ruined for commercial purposes or killed outright, has led the writer to make a thorough investigation of the problem to ascertain the cause of the occasional immunity from borer injury.

As a result of these investigations, it appears practically certain that *plantations of this tree can be protected successfully from*

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[1] *Robinia pseudacacia* L.

[2] *Cyllene robiniae* Forst.

the borer and grown profitably on a commercial scale if the locusts are planted in thick stands or mixed with other trees so as to produce a densely shaded condition and natural pruning during the first 10 to 15 years of growth.

HISTORICAL.

The great variation in the extent of injury by borers to both planted and natural stands of black locust has been noted by many writers. In fact, as early as 1821, Pickering (2)[1] stated that trees of natural growth in groves were much less liable to injury than were transplanted trees. Schwarz (3) in 1890 observed that the insect lives in large colonies affecting all trees of small groves, while long hillsides full of locust are not infested. Cotton (5) observed that in Ohio injury was greater in single trees and plantations of considerable size than in natural forests. Hopkins (6) remarked that "Favorable conditions for the destructive work of the borer appear to be found in the presence of isolated trees and groves in the open. . . . Unfavorable conditions are found in forest growth or large areas of pure stands, or mixed stands where the locust predominates; also, in plantations and groves where resistant varieties prevail, and where there is no goldenrod or other favorite food for the beetles." Dearborn (1), Kellogg (4), and Garman (7) also call attention to this fact.

OBSERVATIONS BY THE WRITER.

In examining locust plantations during the last few years, the writer was greatly impressed with the absolute destruction of some tracts, while others, or parts of the same tracts, were thrifty and unmarred by borers. This was convincing evidence that the trees could be grown so as not to be injured by the locust borer. Many tracts, therefore, both planted and natural, were studied with the idea of securing evidence that might be applicable in a practical way. As far as possible the accurate history of many locust stands, both pure and mixed, was obtained and factors that might be responsible for the presence or absence of injury were weighed. As a result of such study, it was found that the amount of destruction was unquestionably greater in those tracts which had been pruned occasionally, closely grazed, or in which fire had gone through from time to time, killing out the underbrush and destroying the natural shade produced by weeds or shrubbery. The denser the growth, particularly weeds and undergrowth about the stem of the tree, the less was the amount of borer work and vice versa. Pure stands in open fields, where the trees were growing from 2 to 3 feet apart, were seldom injured, while near-by isolated trees were riddled by the borer.

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[1] Reference is made by number in parenthesis to "Literature cited," p. 12.

Possible reasons for such immunity in dense stands were discussed with Dr. A. D. Hopkins in several letters during May, 1910. In a letter of May 11 Dr. Hopkins wrote:

> Perhaps with the unpruned trees there is more shade and, since the beetles are sun-loving and active during the day, the more open and light conditions found in the pruned groves may serve as the attractive influence. This is the only thing I can think of that would make the difference. Observations should be made during the period of flight to determine the relative number of beetles found on trees under shaded and sunny exposures.
>
> If this should lead to a solution of the problem and shaded conditions are favorable, then mixed planting with some quick growing tree like catalpa might be advisable.

This seems a very plausible theory to account for the immunity of unpruned and natural growths, and it is substantiated in the experiments conducted. No other factors considered seem to cover the conditions in the many localities where trees were examined.

INVESTIGATIONS AND EXPERIMENTS.

Natural growths of locust in the vicinity of Falls Church, Va., and plantations along the Pennsylvania Railroad right of ways were selected and used as experimental plats. Some of these near Falls Church were pruned while others were left as they were found. The history of plantations along the Pennsylvania Railroad as to planting and subsequent management has been furnished by the office of the forester of the railroad, which also provided facilities for the study of these plantations.

NATURAL GROWTH IN THE VICINITY OF FALLS CHURCH, VA.

1. On Miners Hill there is a stand of mixed growth of reproduction averaging 3 to 5 inches in diameter. The aspect is a westerly slope, the trees extending from the crest more than half way down the hill. It contains about an acre and is composed chiefly of oak, chestnut, tulip, persimmon, hickory, sassafras, maple, and locust. It is thickly undergrown with weeds and briers which now are dying out. The locust composed about 5 per cent of the stand. In the fall of 1915 these locusts were from 2 to 3 inches in diameter and contained no borers. In January, 1916, one end of this plot, constituting about one-tenth of the area, was pruned; all trees, except the locust, were cut out. The following fall adult beetles were observed ovipositing on the trees thus isolated, and examination in the spring of 1917 showed from 3 to 10 borers in each tree. Again in 1918 these trees were found to be heavily infested. In the remainder of the stand (that which is still growing naturally) about 1 tree in 10 can be found containing one or rarely two defects made by the borer.

2. Just across a road from the tract described above is an old orchard which is used as a pasture. About two dozen locusts of the

same age are growing here. These trees are gnarly, some broken off, and all heavily infested. In the spring of 1918, 10 to 35 larvæ were found in each of these trees. The cattle have kept down the weeds and underbrush which would otherwise protect the trunks.

3. In the same general locality, about one-half mile north of these tracts, lies an abandoned field covered with an almost pure stand of virgin scrub pine 12 to 14 years old. Mixed in this pine are quite a few locusts. During the winter of 1915–16 about an acre of this pine was cleared. The locusts, then averaging 4 inches in diameter, were left standing. None of the trees were infested, as were none of those in the midst of the remaining pine. All were straight, naturally well-pruned, thrifty trees. In the fall of 1916 these trees were attacked by the beetles, and many larvæ were found in them in the spring of 1917. The land has not been cultivated, so that a dense growth of weeds conceals the trunks for 6 to 8 feet above the ground. Scarcely any adults were found on these trees in the fall of 1918, and very few larvæ are expected in the spring of 1919.

In January, 1918, another part of this pine wood was cleared, leaving 15 trees exposed. In July the trees were examined and no borers found nor any evidence of injury in the past. During August and September, 1918, adults were observed ovipositing on these trees.

4. Another abandoned field on an easterly slope contains a clump of about a hundred small locusts, 2 to 6 inches in diameter, grouped about several large trees. These are closely spaced, averaging 2 feet apart. They are well mixed with sumac, tulip, and sassafras. In the surrounding field are many isolated trees. All these isolated trees are scrubby and badly infested by repeated borer attack, while those in the dense clump are tall, thrifty, and contain no borers or defects from past injury.

5. Another abandoned field one-half mile north of Green Gables station on the Washington and Virginia electric line contains several groups of locust from 6 to 18 years of age and many isolated trees. This field contains about 100 acres. Clumps of sassafras and pine mixed with locust and persimmon occupy much of the remaining area. Broom sedge and goldenrod cover the ground on all open spots. All isolated locusts are heavily infested and have been damaged severely by the borers. Many of these trees have fallen over (Pl. I, fig. 1).[1] Three excellent stands of locust occur here; one group of an almost pure stand is composed of trees 25 to 30 feet high and 6 to 8 inches in diameter. They grew very close together and have now thinned out to an average of 10 feet apart. There are more than 500 trees in this plot; all are thrifty and no evidence of borers can be found. They represent what can be grown in 18 years' time on

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[1] The photographs were taken by Mr. R. A. St. George, scientific assistant, Forest Insect Investigations, Bureau of Entomology.

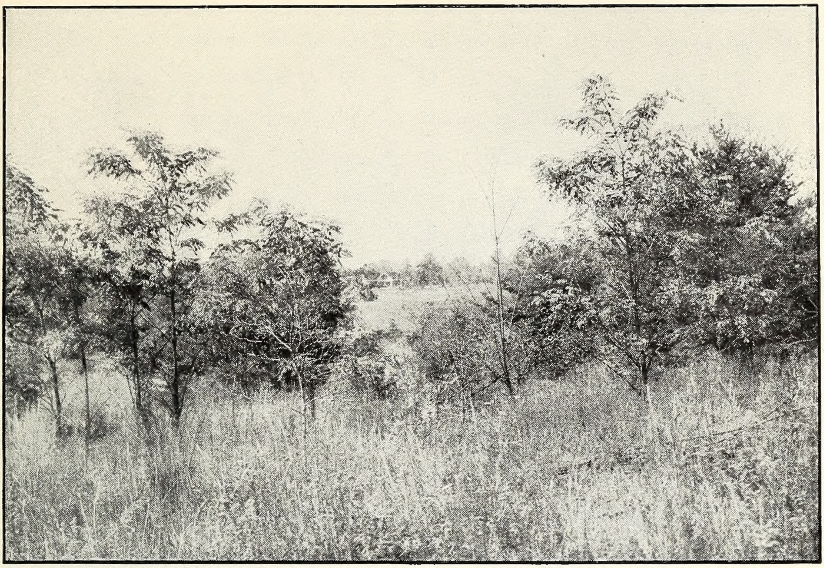

FIG. 1.—NATURAL GROWTH OF LOCUST IN AN OLD ABANDONED FIELD OF SOME 60 ACRES IN EXTENT AT FALLS CHURCH, VA.

Trees badly infested by the locust borer. Several killed and others blown over. Note scattered position. Diameter near base, 2 to 6 inches.

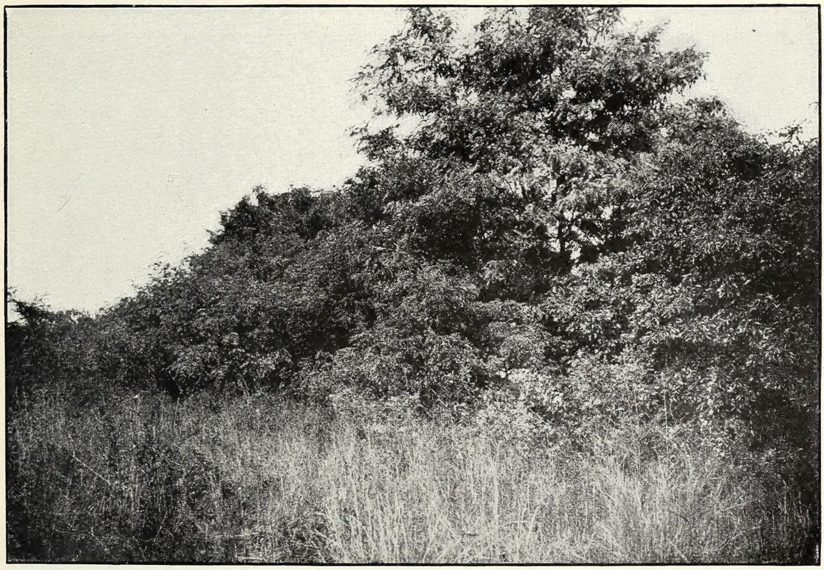

FIG. 2.—NATURAL GROWTH OF LOCUST IN AN OLD ABANDONED FIELD OF SOME 60 ACRES IN EXTENT AT FALLS CHURCH, VA.

Several old seed trees and surrounding root sprouts and seedlings. Note thick growth. None of these trees are infested. Diameter near base, 1 to 8 inches.

PROTECTION FROM THE LOCUST BORER.

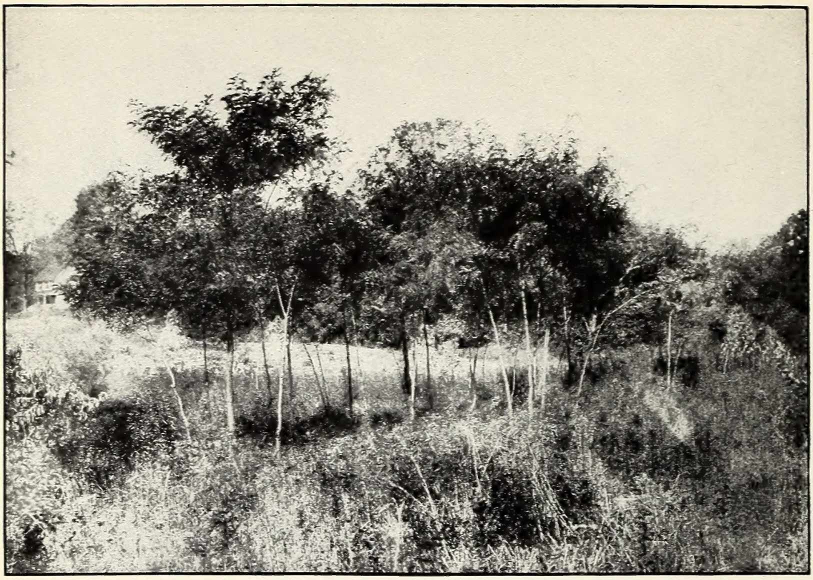

FIG. 1.—NATURAL GROWTH OF LOCUST IN AN OLD ABANDONED FIELD OF SOME 60 ACRES IN EXTENT AT FALLS CHURCH, VA.

An isolated clump of some 30 trees, 2 to 4 inches in diameter. These were growing close together and mixed with tall weeds and sassafras bushes. Illustration after clearing the trunks in July when not a single borer was present. In September these were heavily infested.

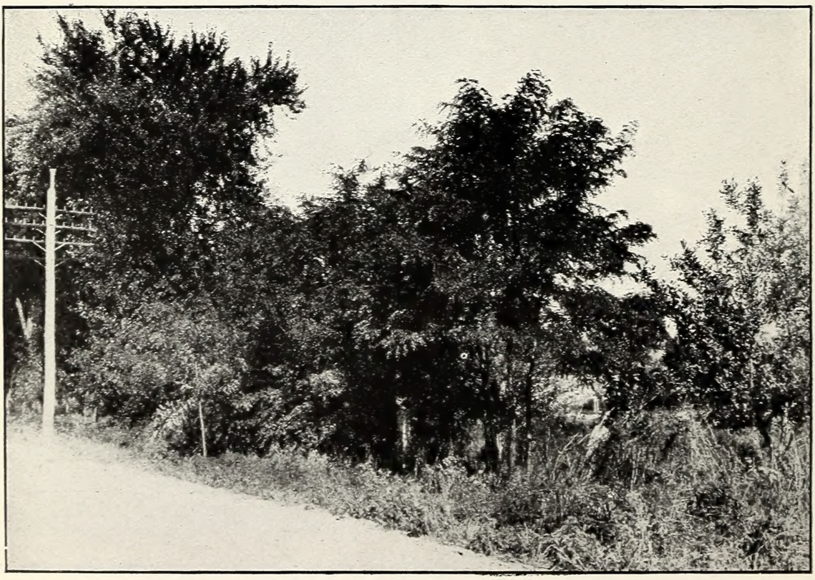

FIG. 2.—ILLUSTRATION OF A FENCE ROW AT FALLS CHURCH, VA., SHOWING THICK LOCUST GROWTH OF 2 TO 5 INCHES IN DIAMETER NEAR BASE.

None of these trees contained borers in July, 1918, when the underbrush and small branches were cleared from the trees in the foreground. These trees were infested in September.

PROTECTION FROM THE LOCUST BORER.

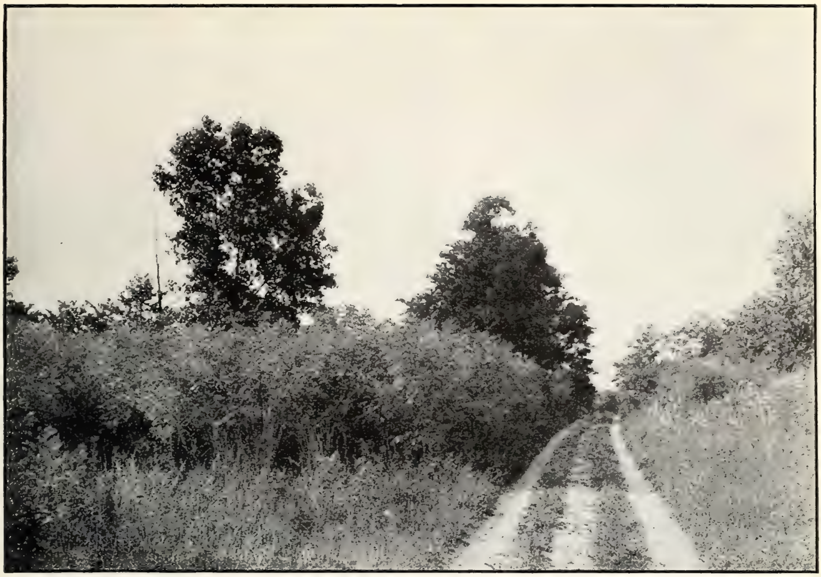

FIG. 1.—A DENSE GROWTH OF ROOT SUCKERS FROM A FEW OLD TREES THAT WERE REMOVED, ON MINERS HILL NEAR FALLS CHURCH, VA.

This illustrates the type of growth that will not be attacked. In the background to the right of the road are many trees containing 5 to 20 borers each. It illustrates the pruned portion of example 1 (see p. 3).

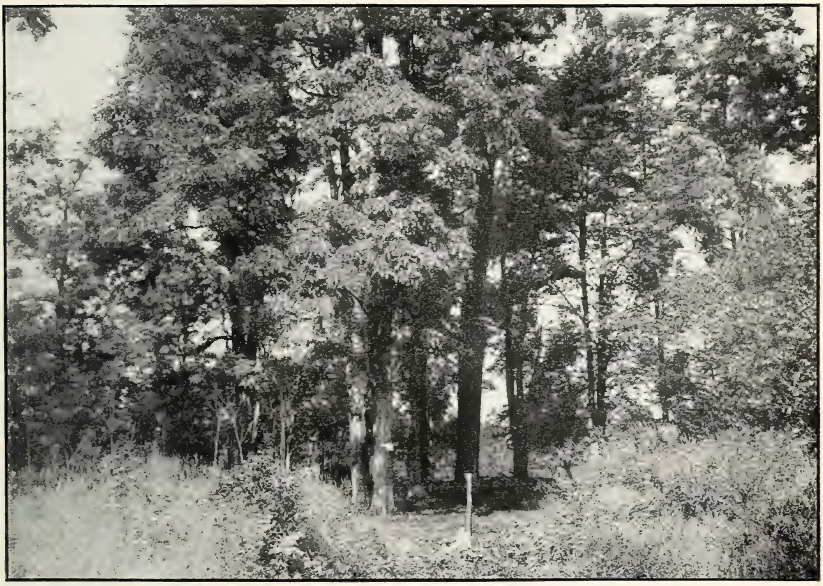

FIG. 2.—LARGE MATURED LOCUSTS AT VIENNA, VA., SHOWING WHAT CAN BE GROWN IN A LOCALITY WHERE THE BORERS ARE VERY ABUNDANT.

These trees show no evidence of borer injury.

old waste land, the soil of which has been enriched by a thick bed of humus beneath the trees.

Another group (Pl. I, fig. 2) near by contains about 30 trees similar in respect to size and conditions. These have seeded the surrounding soil so that a large clump is formed of dense growth, the outermost being some 6 to 8 feet high. None of these trees have been injured by the borer. A third group (Pl. II, fig. 1), forming a small oval clump, contains 38 trees from 2 to 4 inches in diameter and 15 feet high. They were closely set, averaging 4 feet apart. A few sassafras were intermixed. In July, 1918, not one of these trees contained a borer. August 20, 1918, the plot was thinned, all branches trimmed to 8 or 10 feet, and all weeds and briers removed. The trees were closely watched and many adults were observed ovipositing on them during September.[1] Adults were likewise observed on the isolated trees near by, but none in the dense plats described above.

6. A fence row opposite the eastern field station at Falls Church, Va., is densely matted with wild cherry, honeysuckle, and goldenrod along the sides. Through this grow a dozen locusts (Pl. II, fig. 2) 2 to 4 inches in diameter. None of these trees were infested on or previous to August 15, 1918, on which date all the surrounding growth was cleared from four trees. During September adults were observed ovipositing on these four. Many such fence rows exist wherever locust is grown and explain why so little trouble is experienced on the average farm.

7. Along the south bank of the Potomac River between Difficult Run and Scotts Run many locusts are growing on the wooded slope. This stand is a hardwood mixture composed chiefly of oak, chestnut, hickory, tulip tree, basswood, and butternut. All the locusts are tall, straight poles, reaching to the top of the stand, the trees averaging from 6 to 18 inches in diameter. All show a thrifty condition of growth and no borer defects. A low meadow, sometimes cultivated but now pastured, lies between this river terrace and the water. A few occasional locusts grow here, nearly all of which are infested and badly deformed. No goldenrod occurs in the meadow, and the adult beetles were observed to feed on several species of Eupatorium.

PLANTATIONS ALONG THE PENNSYLVANIA RAILROAD.

From the office of the forester of the Pennsylvania Railroad records have been secured of 42 plantations, comprising nearly 2,000 acres, on which over 1,000,000 trees were planted. These trees were about 2 years old when set out and usually were spaced 8 by 8 or 8 by 10 feet. Many of these tracts were personally examined by the writer, accompanied by Mr. I. T. Worthley, assistant forester. The history of each plantation was ascertained as accurately as possible.

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[1] Examination of this plot on Apr. 8, 1919, showed an average of 15 borers per tree.

Some of these tracts are in excellent condition, others almost totally destroyed. It is necessary to describe only a sufficient number of these to give all conditions of culture and past history.

8. Along the line of the railroad, between Philadelphia and Harrisburg, Pa., near Kinzers, are two locust plantations, one on the south side planted in 1904, one on the north planted in 1905. Together they comprise about 25 acres, containing 44,000 trees. As far as can be ascertained, nothing was done in these plots until 1909 and 1910, when thorough prunings took place. The entire tracts were gone over and all the trees trimmed to a single straight stem. All natural growth of other trees or shrubs was thinned out. The writer personally assisted in one of these thinnings in 1910 and at that time noted a few borers in the larger trees. Nothing more was done, but an examination in 1912 showed the borer very abundant and many trees breaking off. At present it is difficult to find a good tree. A few have not been injured sufficiently to cause them to break, but the great majority form a broken tangle. Many root sprouts and suckers are present. These are now meeting the same fate.

9. Near New Brunswick, at Stelton, N. J., are several more plantations in a long strip on the old roadbed comprising some 8 or 10 acres of 13,000 trees. One of these lies along the present roadbed near the station. These trees have been pruned from time to time by the section crews. At present they are badly infested (in the spring of 1918 averaging 10 living borers to a tree) but few broke off until the summer of 1918, when a severe wind destroyed about 5 per cent. These trees average 2 to 5 inches in diameter.

Farther west, some distance from the present roadbed, is a similar stand planted at the same time. No care was taken of it and the trees grew up in thick weeds and other natural, shrubby growth. They are scarcely close enough to produce much natural pruning and all have several large branches. An examination in 1917 and 1918 showed that only a very few trees were infested or ever had been infested. The average diameter is larger than that of those nearer the station.

10. One mile east of Metuchen, N. J., are 10,000 trees planted in 1909, divided into about equal stands, one on the south and one on the north side of the roadbed. The north plot was pruned at two different times, but the years could not be determined. In the spring of 1918 all these trees were badly infested and many were broken off. Many root sprouts and suckers have grown out. The trees on the south side never were pruned or thinned. In the spring of 1918 it was almost impossible to find a borer in the tract; however, a certain amount of old work was present, though not sufficient to mar the trees greatly. These trees were not planted close enough to cause natural pruning and consequently are considerably branched. Very

few root sprouts occur in this tract. They are now producing a more dense shade and natural pruning is taking place. At an earlier date, when the trees were less dense, borers attacked, but as the density increased they probably were repelled before the trees were seriously injured.

The diameter of the stand on the south side averages several inches more than that of the standing trees on the north side. If these trees on the south side had been planted several feet closer, say 6 by 6 instead of 8 by 10 feet, it is the writer's opinion that they would now have unbranched stems with practically no borer defects.

11. On the low-grade freight line between Martic Forge and Columbia, Pa., are five plantations set out in 1906 containing about 150,000 trees. None of these have ever received any attention in the way of pruning. They present conditions varying from such as described at Kinzers (example 8) to almost perfect stands free from borer injury. In no single plantation are the trees all destroyed or all in good condition, but the extremes are found in different parts of each tract. Another factor has been responsible here. A definite correlation exists between those parts of the plantation that have been run over by fire and those parts which were by nature of their position less subject to fire. Where fire has burned over repeatedly, killing the undergrowth, the worst destruction by borers is found. In many places the locusts themselves have been killed. One tract near Shenks Ferry attracted particular attention. It extends from the roadbed across a bottom and up over a hillside. Fire no doubt has gone through the part near the tracks repeatedly, as evidenced by the different ages of scars on the standing trees. Here there is little undergrowth; the locusts are scattered (many have been fire-killed), and all are severely infested. On the hillside and over the crest, fires, for some reason, have not gone through. The locusts have grown up in a dense stand mixed with much underbrush, and oak and chestnut sprouts from the original stumpage. These trees are now in excellent condition; they are tall, straight, thrifty, not branched, and free from borer defects. In some parts the shade of the mixed stand has become so dense that all weeds, briers, and underbrush have been shaded out.

12. Along the railroad between Harrisburg and Huntingdon, Pa., much locust has been planted, and many natural stands occur. The condition of the locust in this region is generally so much better and so much more thrifty that the first examination gave the impression that it is an exceptionally favorable situation for the growth of the tree. It is no doubt true that certain localities are better adapted to the growth of black locust, but the essential factor in this location is considered to be more than purely a favorable situation. The locusts are growing in a narrow belt of river terrace from a few

yards to a mile wide between the foot of the mountain and the Susquehanna and Juniata Rivers. There is much humidity, and all vegetation is vigorous.

It is believed that the good condition of these locusts and the decided absence of injury by borers are due to the fact that the situation is conducive to a rapid growth of underbrush and plants characteristic of river shores which have afforded protection to the locusts. This is further emphasized by the fact that in other localities are found trees of equal size and good appearance, as described at Shenks Ferry (example 11), of the same age. Also in the same locality we find trees deformed and aborted by borer injury, as described in the following paragraph.

13. Along the Juniata River between Newport and Old Ferry, Pa., a continuous plantation of locust set out in 1904 extends for a distance of 2 miles. These trees, especially that part near Newport, show the best stand of all the plantations. After planting no attention was given them until 1914, when they were thinned to afford a view of the river from the trains. At this time most of the stems had reached a sufficient size to be immune from borer attack. The trees nearest Newport now average 5 to 8 inches in diameter. They are straight, free from branches, and about as tall as the telegraph poles near by. The bark is ridged naturally, showing absence of borer injury in the past. Nothing definite as to how these trees grew in the period intervening between planting and first pruning could be ascertained, but from a study of many plots of all ages along the river it is certain that they were intermixed with a dense growth of other shrubs and weeds. Natural pruning and thinning have taken place to such an extent that few living branches are found below the crown, and many trees have been suppressed and killed. Farther back from the railroad, where no pruning at all was done, the dead, suppressed trees and shaded-out branches give a good idea as to how rapidly this process takes place in the tree.

In this 2-mile strip of locusts the borers are serious in two places and have caused many trees to break off or have stunted the growth badly. In one of these places fire has gone through: the other was evidently pruned (as shown by scars) to afford a view of a pond just behind. These last trees were also isolated in the sense that the rows were only two trees deep. These trees average scarcely half the diameter of those in the better parts of the grove.

CONDITION OF TREE NECESSARY FOR BORER ATTACK.

All trees and all parts of the tree are not subject to attack by the borer to the same degree.

Moderately rough bark seems to be an essential condition, since it provides the necessary crevices in which the adults deposit their eggs.

Likewise, until they become 1½ to 2 inches in diameter at the base, trees are not subject to attack unless the bark is rough. On younger trees the borers are found concentrated at the base and near crotches.

For some unknown reason trunks of trees reaching 5 to 6 inches in diameter and over (excepting old brood trees) rarely are found to contain borers. On such trees the larger branches frequently are infested, but such injury is seldom common enough to do much harm or even attract attention. It can be said, therefore, that protection from borer injury is necessary for only a comparatively short period during the tree's growth. Under good growing conditions this time should not exceed 10 years.

In every locust grove that has borers present, certain trees will be found on which they have concentrated. These are called brood trees. The thick, irregularly barked, gnarled appearance and stunted growth will distinguish such individuals. They are often continuously infested until they reach an old age, or 12 to 18 inches in diameter.

HOW TO RECOGNIZE TREES CONTAINING NO BORER DEFECTS.

The larval mine made by the locust borer destroys a certain amount of the growing tissue or cambium and makes a serious defect in the wood. This injury to the cambium accelerates growth to heal it over and produces a swollen or gnarly appearance. Many such defects give the entire stem a roughened, distorted shape. The bark is irregular and scaly. On the other hand, trees that have not been injured by the borer are characterized by very regular bark, which is grooved longitudinally between thick, dark ridges. With a little experience these features can be quickly recognized and until the tree reaches 10 to 12 inches in diameter it is possible to determine accurately whether the borer defect will be found in the wood.

CHARACTER OF GROWTH OF UNINFESTED STANDS.

Not only is the appearance of uninjured individual trees characteristic but pure stands of such trees have a different appearance from those that are damaged. The tops of isolated natural stands have a domelike outline, the innermost trees growing taller and straighter, while root sprouts continuously coming up around the borders form smaller and younger trees which give additional protection to those within. These younger trees are at first too small for infestation, and when they have reached a susceptible size are protected in their turn. The crowns are uniformly shaped and no branches project to break the contours. Planted stands, where the trees are of the same age, are uniform in height, the tops forming a flat outline. No large branches are found on the trunks, but many small, naturally pruned dead branches are seen and many trees are thinned out naturally as the others increase in size. Few root sprouts appear. Infested plantations are very irregular in outline; broken tops, trees of irregular size, and many root sprouts and suckers are characteristic indications of borer damage.

CONDITIONS UNDER WHICH LOCUST CAN BE GROWN.

From the history of the foregoing tracts it is evident that black locust can be grown profitably under circumstances that require little care, or, in fact, better results are obtained without too much attention. After comparing all the data available it seems that *provision for sufficient shade during the period of growth subject to borer attack* is all that is necessary in order that this tree may be grown successfully.

This can be achieved by some system of close and mixed planting. Experiments of such a character should be tried. In nature it is accomplished by close reproduction coming up around the seed tree, by root sprouts from older trees, or often by the mixture of other plants growing with the locusts. Weeds and vines often form the needed shade, as illustrated by trees in old fence rows. It is very essential that this shade be present after the trees reach 1½ to 2 inches in diameter, and that it be continued until they attain 5 or 6 inches. After this time thinning and pruning can be done with little or no subsequent injury by the borers.

Close planting or thick growth of these trees also is necessary to produce straight, unbranched boles. Trees in the open are always much branched and rather crooked, but those grown in forests are tall, straight, and naturally pruned while the branches are quite small.

That difference in site or locality is not the influencing factor in the growing of uninjured trees is evident from the fact that in every locality examined it was possible to find examples of borer-free and destroyed trees growing 100 yards apart. It is also evident that goldenrod is not necessarily associated with greater damage by the borer, for in the same abandoned field, massed with this plant, were found plots of trees absolutely free from injury and near-by isolated trees badly infested. Again, localities where no goldenrod is growing may have borer-infested trees, the adults feeding on other composites, as illustrated by example 7.

The idea has been advanced that the borers are more abundant in some localities than in others and that this will account for the difference in infestation. This difference can not be sustained, as the beetles are present everywhere within the natural range of this tree. Side by side we find stands of badly infested trees and trees containing no borers. It is rather to be believed that in localities where locust was planted the beetles present either remained in about the same numbers or increased enormously, according as the condition of the trees retarded or favored their increase. In no new locality where plantations were put out would there be enough beetles present to infest all the trees. They only attack all the trees as they become sufficiently numerous.

CONTROL.

A METHOD OF HANDLING SEVERELY DAMAGED PLANTATIONS.

Many locust plantations have been abandoned and all hope of ever realizing any commercial product given up because of the severe devastation produced by the borers. Such tracts look hopeless with the greater percentage of the trees broken off or killed, but it is believed that they can be reclaimed after several seasons' care by virtue of the sprouting ability of this tree.

It is recommended that all such plantations be gone over and the broken-down and infested trees removed and burned during the winter. Unless otherwise desired it would be necessary to cut out only the living infested trees, because no beetles will breed in the dead ones. Especial attention should be given to the seriously damaged or so-called brood trees. If the cutting out of the infested trees can be done early in November it is not necessary to destroy or burn the wood. The larvæ require living wood for their early development and will not mature in dead material. This not only will reduce the numbers of the insects, but before the sprouts become large enough to be attacked a sufficiently dense stand will have been developed to provide natural protection, as illustrated in Plate III, figure 1.

TREATMENT OF SHADE TREES.

The locust is widely planted for ornamental and shade purposes. It is very desirable for such planting, because of its ability to succeed well in a variety of soils and situations and its rapid growth and good form of crown in the open. We often hear complaints of serious injury by the borer to locust shade trees; this is because such trees are usually grown in isolated situations most favorable for attack.

It has been found that the young borers can be killed readily by the use of an arsenical spray, applied to the bark when the new growth begins to open at the tips of the twigs in the spring. It is necessary to apply this mixture so thoroughly as to cover all parts of the trunk and reach every spot where a larva is working.[1]

A thorough application will probably be necessary only every two years unless there are badly infested trees near by which are not treated and form centers of reinfestation. As a rule, spraying will not be necessary after the trees reach 6 inches in diameter or such a size that they are immune from attack. Isolated trees, however, are sometimes exceptions to this and should be watched.

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[1] The presence of a young borer can be determined by the oozing of sap and boring dust from a small hole through the bark. This hole is enlarged as the larva grows.

Many spray solutions have been tried by the writer, but by far the most successful has been the combination of a soluble arsenate with an oil emulsion. This provides a penetrative poison which enters the exudation pores made by the larvæ through the bark and poisons the inner bark on which the young larvæ feed. Insoluble arsenates are not so effective, as the exudation pore is usually plugged with a wad of fine granular frass from which the arsenate in suspension filters out. Kerosene emulsion can be used to carry the arsenical, but it has been found that the miscible oils are just as satisfactory and require much less time in preparation.

The formula and preparation are as follows:

Dissolve ¼ pound of sodium arsenite or arsenate in 5 gallons of water. Add 1 quart of miscible oil and agitate thoroughly.

With kerosene emulsion, dissolve ¼ pound of the arsenical in 4 gallons of water and add 1 gallon of stock solution of kerosene emulsion, agitating thoroughly.

LITERATURE CITED.[1]

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[1] Other papers dealing with the locust borer will be found in the bibliography given by Dr. A. D. Hopkins in the bulletin entitled "Some insects injurious to forests: The locust borer." (U. S. Dept. Agr., Bur. Ent. Bul. 58, pt. I.)

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